Claims

1. A method for measuring a dimension on a substrate, the method comprising the steps of:

providing a target pattern on a substrate, said target pattern corresponding to a nominal pattern, said nominal pattern comprising an array of features characterized by a primary pitch of period *P* in a primary direction, said nominal pattern further characterized by a characteristic dimension defined along a direction substantially orthogonal to said primary direction, wherein said target pattern has a substrate characteristic dimension corresponding to said characteristic dimension of said nominal pattern;

illuminating said target pattern with radiation characterized by at least one wavelength, so as to produce diffracted radiation from said target pattern;

providing a relationship for determining a dimension of interest along said primary direction in said target pattern as a function of a measurable quantity of one or more non-zeroth orders of said diffracted radiation along said substantially orthogonal direction to said primary direction, said measurable quantity of said one or more non-zeroth orders occurring in response to said substrate characteristic dimension in said target pattern;

detecting said measurable quantity of said one or more non-zeroth orders of said diffracted radiation; and

determining said dimension of interest in accordance with said relationship, based on said detected measurable quantity of said one or more non-zeroth orders of said diffracted radiation.

2. The method of claim 1 wherein said dimension of interest comprises a feature width of said features comprising said array of features in said target pattern.

3. The method of claim 2 wherein said characteristic dimension of said nominal pattern comprises a width of said features of said array that varies continuously along said substantially orthogonal direction.

4. The method of claim 3 wherein said characteristic dimension varies continuously according to a predetermined taper angle along said substantially orthogonal direction.

5. The method of claim 2 wherein said characteristic dimension of said nominal pattern comprises a width of said features of said array that varies discretely along said substantially orthogonal direction.

6. The method of claim 2 wherein said measurable quantity comprises the location of an extrema of intensity of said one or more non-zeroth orders along said substantially orthogonal direction.

7. The method of claim 2 wherein said nominal pattern comprises a first region having a first center position and a second region located adjacent to said first region, said second region having a second center position at a predetermined distance from said first center position along said substantially orthogonal direction, and said target pattern having corresponding first and second regions on the substrate, and wherein said measurable quantity comprises the distance between the location of an extrema in said one or more non-zeroth orders from said first region of said target pattern and the location of an extrema in said one or more non-zeroth orders from said second region of said target pattern.

8. The method of claim 1 wherein said measurable quantity comprise intensity of said one or more non-zeroth orders along said primary direction.

9. The method of claim 1 wherein said target pattern comprises a first region having features of a first tone, and a second region having features of a second tone different from said first tone, wherein the method further comprises comparing measurements obtained from said first region with measurements obtained from said second region to determine effects of process conditions.

10. The method of claim 9 wherein said process conditions are selected from the group consisting of dose, focus or a combination thereof.

11. The method of claim 1, wherein said nominal pattern comprises a first subarray of first features and a second subarray of second features, each subarray characterized by pitch P, wherein said first subarray and said second subarray are positioned so that said first features are positioned by a predetermined offset along said primary direction from said second features, and wherein said target pattern comprises a first target subarray corresponding to said first subarray having a first reflectivity and said target pattern further comprises a second target subarray corresponding to said second subarray having a second reflectivity, wherein said first and second target subarrays are characterized by an offset on the substrate corresponding to said predetermined offset, and wherein said dimension of interest comprises a difference between said offset on the substrate and said predetermined offset.

12. The method of claim 11 wherein said one or more non-zeroth orders comprises positive non-zero orders and the corresponding negative non-zero orders of said diffracted radiation.

13. The method of claim 12 wherein said measurable quantity comprises intensities of said one or more non-zeroth orders, and said relationship further comprises determining an effective amplitude and an effective phase difference between said first reflectivity of said first target subarray and said second reflectivity of said second target subarray.

14. The method of claim 11 wherein said predetermined offset varies continuously along said substantially orthogonal direction.

15. The method of claim 11 wherein said predetermined offset varies discretely along said substantially orthogonal direction.

16. An apparatus for performing the method of 1 comprising:

a source of radiation for illuminating said target pattern;

collection optics configured to collect said one or more non-zeroth orders along said primary direction and to image said target pattern along said substantially orthogonal direction; and

a detector array configured to detect spatial variations of said one or more non-zeroth orders from said collection optics along said substantially orthogonal direction and along said primary direction.

17. The apparatus of claim 16 further comprising a computer system comprising a computer readable storage medium, said computer readable storage medium comprising instructions for causing said computer system to determine said dimension of interest in accordance with said relationship, based on said detected measurable quantity of said one or more non-zeroth orders of said diffracted radiation.

18. The apparatus of claim 16 further configured to provide a second detector for detecting zeroth order radiation diffracted from said substrate, said apparatus further comprising means for determining film thickness from said zeroth order radiation.

19. The apparatus of claim 16 wherein said apparatus is configured for in-line processing for semiconductor manufacturing.

20. The apparatus of claim 19 wherein said target pattern comprises a first region having features of a first tone, and a second region having features of a second tone different from said first tone, wherein the method further comprises comparing measurements obtained from said first region with measurements obtained from said second region to determine effects of process conditions.

21. The apparatus of claim 20 wherein said process conditions are selected from the group consisting of dose, focus or a combination thereof.

22. The apparatus of claim 20 further comprising means for determining a deviation in said process conditions from nominal process conditions based on said dimension of interest.

23. The apparatus of claim 22 further comprising means for providing adjustments in subsequent process conditions in response to said deviation in process conditions.